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FACTOR STRUCTURE OF THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB), FORMS 8, 9, AND 10: 1981 ARMY APPLICANT SAMPLE

Richard A. Kass, Karen J. Mitchell,
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The purpose of this paper is to examine the factor structure of the Armed Services Vocational Aptitude Battery (ASVAB), Forms 8, 9, and 10. This standardized multiple cogntive abilities battery is the primary selection and classification instrument used by all military services. It consists of eight power and two speed tests. This investigation compared the ASVAB 8/9/10 factor structure to the factor structure observed for previous samples and previous forms of the ASVAB; it examined the similarity of ASVAB factor structure for racial/ethnic and sex subgroups. A factor analysis of a sample

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20. of 98,689 male and female Army applicants yielded four orthogonal factors accounting for 93% of the total variance: Verbal Ability, Speeded Performance, Quantitative Ability, and Technical Knowledge. Factor analyses of male, female, white, black, and Hispanic subgroups yielded similar results.

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FOREWORD

The Selection & Classification Technical Area of the Army Research Institute for the Behavioral & Social Sciences (ARI) is concerned with developing effective procedures for the selection of applicants into military service and for the classification of accessions into Army occupational specialties. This research examined and documented selected psychometric properties of the current Department of Defense military selection and classification battery, the Armed Services Vocational Aptitude Battery (ASVAB) 8/9/10. The factor analysis yielded four orthogonal factors accounting for 93% of the total variance.

Edgar M Johnson
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Technical Director

FACTOR STRUCTURE OF THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB), FORMS 8, 9, AND 10: 1981 ARMY APPLICANT SAMPLE

BRIEF

Requirement:

To examine the factor structure of the Armed Services Vocational Aptitude Battery (ASVAB), Forms 8, 9, and 10 and to compare the ASVAB 8/9/10 factor structure to the factor structure observed for previous samples and previous forms of the ASVAB.

Procedure:

A principal components factor analysis of data for a 20% random sample of FY81 Army applicants was computed. Subtest reliabilities were used as diagonal entries. Initial solutions were rotated to varimax simple structure. Analyses were repeated for male, female, white, black, and Hispanic subgroup data.

Findings:

A factor analyses of 98,689 FY81 Army applicants yielded four orthogonal factors accounting for 93% of the total variance: verbal ability, speeded performance, quantitative ability, and technical knowledge. Factor analyses for previous forms of the ASVAB and for male, female, white, black, and Hispanic subgroups yielded similar results.

Utilization of Findings:

These analyses speak to the factor content of the Armed Services Vocational Aptitude Battery and affirm the invariance or constancy of factor content across forms and population subgroups. The data also relate to the construct validity of the operational ASVAB and provide information relevant to future test development efforts.

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FACTOR STRUCTURE OF THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB), FORMS 8, 9, and 10: 1981 ARMY APPLICANT SAMPLE

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FACTOR STRUCTURE OF THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB), FORMS 8, 9, AND 10: 1981 ARMY APPLICANT SAMPLE

INTRODUCTION

The purpose of this report is to present to the wider scientific community a description of the psychometric properties of the current Armed Services Vocational Aptitude Battery (ASVAB) (U.S. Department of Defense, 1979) as administered to a representative sample of applicants for military service. The factor structure of this battery was examined by comparing the ASVAB Forms 8/9/10 factor structure to the factor structure observed for previous samples and previous forms of the ASVAB. The similarity of factor structure for racial/ethnic and sex subgroups was also considered for the purpose of establishing the possible invariance of the factorial validity of ASVAB across diverse samples.

The Armed Services Vocational Aptitude Battery

Since 1976 all Armed Services have used the ASVAB as the primary instrument for selection and classification. To be selected for military service, all applicants need to achieve a minimum score on a composite of four ASVAB subtests called the Armed Forces Qualification Test (AFQT). In addition, the separate services use various combinations of the ASVAB subtests called Aptitude Area composites to generate scores for occupational classification.

The ten subtests of the ASVAB are listed in Table 1. The current ASVAB, in operational use since 1 October 1980, consists of six parallel forms: 8a, 8b, 9a, 9b, 10a, and 10b. Each form contains unique item sets for the four subtests included in the AFQT composite: Arithmetic Reasoning, Word Knowledge, Paragraph Comprehension, and Numerical Operations. For the six remaining subtests, only three unique item sets exist. Test forms 8a and 8b, for example, contain the same sets of items for these six subtests although the order of items is different. Since the six forms of the ASVAB have been shown to yield equivalent scores (Ree, Mathews, Mullins, and Massey, 1981), the data analysis to be presented did not distinguish among the forms.

Table 1 also provides the number of items per subtest and the testing time limits. Although all 10 subtests are individually timed, only Numerical Operations and Coding Speed are considered speed tests. The remaining eight subtests are essentially power tests with administrative time limits. The means and standard deviations included in Table 1 were computed for the subtest raw scores in the sample of Army applicants to be described. Estimates of subtest reliabilities for the eight power subtests for each of the six forms of ASVAB 8/9/10 were derived from Ree, Mullins, Mathews, and Massey (1981). Subtest reliabilities estimated for each sex and racial/ethnic subgroup for the eight power tests differed only minimally; absolute differences ranged from .00 to .14 (Bock and Mislevy, 1981). Reliability estimates for the two speeded subtests were obtained from Sims and Hiatt (1981) and Wilfong (1980).

Table 1

ASVAB 8/9/10 Subtests

Subtest Name	Description	Number of Items	Test Time (Min.)	20% of Army Applicants for FY81: Mean	20% of Army Applicants for FY81: Standard Deviation	Reliability
General Science (GS)	Knowledge of the physical and biological sciences	25	11	14.3	5.2	.86[a]
Arithmetic Reasoning (AR)	Word problems emphasizing mathematical reasoning rather than mathematical knowledge	30	36	16.4	6.8	.91
Word Knowledge (WK)	Understanding the meaning of words, i.e., vocabulary	35	11	23.1	7.9	.92
Paragraph Comprehension (PC)	Presentation of short paragraphs followed by one or more multiple choice items	15	13	9.7	3.5	.81
Numerical Operations (NO)	A speeded test of four arithmetic operations, i.e., addition, subtraction, multiplication and division	50	3	34.2	10.5	.78[b]
Coding Speed (CS)	A speeded test of matching words and six digit numbers	84	7	42.8	15.1	.85[c]
Auto Shop Information (AS)	Knowledge of auto mechanics, shop practices and tool functions in verbal and pictorial items	25	11	14.6	5.7	.87
Mathematics Knowledge (MK)	Knowledge of algebra, geometry and fractions	25	24	11.3	5.2	.87
Mechanical Comprehension (MC)	Understanding mechanical principles such as gears, levers, pulleys and hydraulics in verbal and pictorial items	25	19	13.5	5.2	.85
Electronics Information (EI)	Knowledge of electronics and radio principles in verbal and pictorial items	20	9	11.1	4.0	.82

[a] Mean internal consistency reliability estimate for powe[illegible] McNemar (1969) for computational procedure as reported in Ree, Mullins, Mathews, & Massey [illegible].

[b] Parallel form reliability estimate as reported in Sims & [illegible]att (1981).

[c] Mean parallel form reliability estimate as reported in Wilfong (1980).

Previous ASVAB Investigations

Fischl, Ross, and McBride (1979) investigated the factor structure of an earlier form of the ASVAB, Form 5, which is currently used in the Department of Defense (DoD) high school testing program (Wilfong, 1980). Fischl et al. used test results from 2,052 male and female high school students and reported five oblique factors. These factors (unnamed by the authors) represented comprehension of verbal material, speed and accuracy in the performance of simple mathematics and coding tasks, knowledge of quantitative principles, understanding of mechanical principles, and knowledge of automotive/shop practices. More recently Ree, Mullins, Mathews, and Massey (1981) used responses from 15,115 male service-wide applicants to factor each of the six ASVAB 8/9/10 forms. Ree et al. accepted an oblique four factor solution as the most interpretable. The four factors across the six test forms represented: verbal, clerical/speed, mathematical, and vocational-technical constructs. The correlations among these oblique factors for all the six test forms ranged from .20 to .60.

The present analyses were concerned with the determination of (a) the factor structure of ASVAB 8/9/10 in an unweighted sample of male and female Army applicants and (b) the degree of similarity of ASVAB factor structure for racial/ethnic and sex subgroups.

METHOD

Subjects

During Fiscal Year 1981 (FY81), October 1980 through September 1981, ASVAB Forms 8, 9, and 10 were administered to over one million Armed Forces applicants. The Army Research Institute for the Behavioral and Social Sciences (ARI) received on a monthly basis the test results of all military applicants during FY81. Each month's applicants were computer screened to obtain a random sample of 20% of the active Army applicants. Those who had been previously tested with the ASVAB were eliminated. A total sample of 98,689 active Army applicants resulted.

The sample included 18,728 (19%) females and 79,926 (81%) males with 35 cases missing a gender identification. The sample contained 15,151 (15%) high school seniors, 46,542 (47%) high school diploma graduates, 32,866 (33%) applicants with less than a high school diploma (excluding high school seniors expected to receive diplomas), and 4,093 (4%) with post high school education. Thirty-seven cases were missing an education identification. The racial/ethnic composition of the total sample was 62,389 (63%) white, 29,546 (30%) black, and 656 (1%) Hispanic examinees. The remaining 6% included Asian Oriental, American Indian, other, and unknown.

Procedure

The factor analysis proceeded as follows. Subtest intercorrelations were computed for the 20% aggregate sample of FY81 Army applicants. The factoring method used was a principal factors solution with subtest reliabilities (as reported in Table 1) being employed as communality estimates. Subtest reliabilities were used as diagonal entries to permit analysis of the total

nonerror variance. The initial factor solutions were rotated to varimax simple structure solutions. Varimax was chosen to facilitate comparisons of factor structure across solutions and subgroups. Selection of the best factor solution involved examination of the two- through five-factor solutions.

As the sample sizes for some sex-by-racial/ethnic groups were quite small, subtest intercorrelations were computed for the two sex groups and the three racial/ethnic groups instead of the six sex-by-racial/ethnic groups. A factor analytic approach identical to that used for the total sample was adopted for each of the five sex and racial/ethnic group matrices. Subtest reliabilities estimated for each sex and racial/ethnic subgroup were reported by Bock and Mislevy (1981) subsequent to the calculation of these analyses. The subgroup reliabilities were judged similar enough to warrant maintaining the aggregate group reliabilities as diagonal entries for all groups.

RESULTS

Table 2 presents the subtest intercorrelations and factor structure matrix for the aggregate sample of Army applicants. The intercorrelations were all positive and moderately high ranging from a low of .250 to a high of .813 with a median correlation of .593. The two-, three-, four-, and five-factor solutions accounted for 83%, 89%, 93%, and 95% of the total variance, respectively. The two-factor solution consisted of a general power factor and a specific speeded performance factor (CS and NO). The subsequent three- and four-factor solutions included a successively decreasing general factor with new specific factors reflecting quantitative ability (AR and MK) and technical knowledge (AS, MC, and EI), respectively. The first four factors in the five-factor solution were identical to the four-factor solution. The fifth factor in this unrotated solution had an eigenvalue of .15; the fifth factor in the rotated solution did not have a factor loading above .26. Consequently, the four-factor solution was accepted as the most psychologically meaningful representation of the ASVAB structure for the aggregate sample. It accounted for the maximum amount of variance in the correlation matrix prior to the formation of a factor with only low factor loadings. To facilitate interpretation of the four-factor solution, .50 was used to define salient factor loadings. Inspection of the pattern of factor loadings suggested identifying the four factors as Verbal Ability, Speeded Performance, Quantitative Ability, and Technical Knowledge, respectively.

The four-factor solution was quite similar to four oblique factors obtained by Ree, Mullins, Mathews, and Massey (1981). The one difference in the solution for the present Army sample in comparison to that in the sample they employed was that General Science (GS) was more complex in that it had a high factor loading on both the Verbal Ability and Technical Knowledge factors. In their sample, GS had only one dominant loading, on the Verbal Ability factor.

The present results were also compared to those obtained previously for ASVAB Form 5 by Fischl et al. (1979). There was a clear correspondence between the Speeded and Quantitative factors for Form 5 and the Speeded Performance and Quantitative Ability factors for Forms 8, 9, and 10. Moreover, Form 5 factors for Mechanical Comprehension and Automotive/Shop were included in the Technical Knowledge factor of Forms 8, 9, and 10; whereas the Form 5 Verbal Ability Factor corresponded to Verbal Ability of Forms 8, 9, and 10. The one exception was that, in the present analysis, the Electronics Information subtest had a dominant

Table 2

ASVAB Subtest Intercorrelations and Factor Structure Matrix
for Fiscal Year 1981 Army Applicants (N=98,689)

	Subtest Intercorrelations									Factors				
	GS	AR	WK	PC	NO	CS	AS	MK	MC	I	II	III	IV	h^2
General Science (GS)										63	18	34	52	80
Arithmetic Reasoning (AR)	684									33	32	68	40	83
Word Knowledge (WK)	813	683								77	27	27	41	90
Paragraph Comprehension (PC)	718	662	794							66	34	28	35	75
Numerical Operations (NO)	426	557	486	512						21	74	31	12	70
Coding Speed (CS)	372	462	446	469	661					17	86	12	13	80
Auto Shop Information (AS)	656	562	609	546	287	250				25	11	13	85	82
Math Knowledge (MK)	626	765	608	587	533	443	440			28	30	76	27	82
Mechanical Comprehension (MC)	686	658	631	593	356	321	720	584		24	16	37	74	77
Electronics Information (EI)	710	607	678	604	342	302	745	528	706	37	14	23	73	75
Eigenvalues of Unrotated Factors										6.02	1.09	.44	.39	

Note: Decimal points omitted for correlations, factor loadings and communalities.

factor loading on Technical Information. In the Form 5 analysis, Electronics Information was more complex than in the analyses for other forms. Moderate factor loadings occurred on both the Verbal Ability and Technical Information Factors.

Table 3

Factor Structure Matrices for Male and Female Army Applicants for Fiscal Year 1981

ASVAB Subtests	Female (N=18,728) I	II	III	IV	h^2	Male (N=79,926) I	II	III	IV	h^2
General Science (GS)	<u>69</u>	14	32	42	77	<u>62</u>	19	36	<u>51</u>	81
Arithmetic Reasoning (AR)	38	28	<u>70</u>	31	81	33	33	<u>69</u>	38	84
Word Knowledge (WK)	<u>80</u>	21	26	34	87	<u>75</u>	26	28	44	90
Paragraph Comprehension (PC)	<u>70</u>	28	30	26	72	<u>64</u>	32	30	40	75
Numerical Operations (NO)	22	<u>72</u>	31	07	67	22	<u>73</u>	33	14	70
Coding Speed (CS)	13	<u>85</u>	10	17	78	16	<u>85</u>	14	20	80
Auto Shop Information (AS)	33	17	17	<u>77</u>	75	30	18	15	<u>82</u>	82
Math Knowledge (MK)	30	26	<u>77</u>	22	80	28	30	<u>77</u>	26	82
Mechanical Comprehension (MC)	23	13	<u>50</u>	<u>62</u>	70	26	20	40	<u>71</u>	77
Electronics Information (EI)	46	14	21	<u>59</u>	62	41	19	25	<u>69</u>	75
Eigenvalues of Unrotated Factors	5.63	.95	.50	.41		6.28	.91	.44	.32	

Note: Decimal points omitted from factor loadings.

<u>Gender</u>

Investigation of possible differences between male and female applicants revealed that correlations for males were consistently higher than the corresponding correlations for females, although these differences were not great. The absolute difference between the two sets of correlations ranged from a low of .006 to a high of .165 with a mean absolute difference of .075. Selection of the most interpretable factor solution for male and female subgroups involved examination of the two- through five-factor solutions. The similarity between the subgroup correlation matrices is reflected in the factor analytic results for the four-factor solution in Table 3. As expected the factor loadings for

males were nearly identical to those in the aggregate sample. There were virtually no differences between males and females for Verbal and Speeded Performance. For Quantitative Ability and Technical Knowledge, however, small differences were observable. For females, Mechanical Comprehension had a higher loading on Quantitative Ability whereas General Science had a lower loading on Technical Knowledge. In addition, for the five-factor solution (not reproduced in this paper), the Technical Knowledge factor for females split, with AS and EI defining one factor and MC defining the second. The eigenvalue for the unrotated fifth factor was .26. The technical knowledge construct as defined by the ASVAB subtests, thus, appears more complex for females than for males.

Table 4

Factor Structure Matrices for White, Black, and Hispanic Army Applicants for Fiscal Year 1981

	Factors														
ASVAB	White (N=62,389)					Black (N=29,546)					Hispanic (N=656)				
Subtests	I	II	III	IV	h^2	I	II	III	IV	h^2	I	II	III	IV	h^2
Gen. Sci. (GS)	65	16	34	47	79	72	11	27	38	74	65	-03	30	40	66
Arith. Reas. (AR)	34	33	70	35	83	31	25	72	29	76	28	12	75	30	74
Word Know. (WK)	79	27	26	35	89	80	24	24	32	85	87	-02	18	21	83
Para. Comp. (PC)	67	33	28	33	74	68	33	26	23	69	77	01	10	26	67
Num. Oper. (NO)	21	74	32	10	70	21	74	30	09	68	-17	67	38	-13	64
Coding Speed (CS)	17	86	13	10	79	16	86	10	09	78	09	88	01	-05	78
Auto/Shop Info. (AS)	22	08	10	86	81	25	07	08	81	73	27	-07	-06	82	76
Math Know. (MK)	30	31	76	24	82	26	22	78	19	75	17	15	84	10	77
Mech. Comp. (MC)	25	13	39	72	75	16	11	33	71	66	22	-01	29	73	66
Elec. Info. (EI)	38	12	22	73	74	39	09	16	67	64	23	-14	21	69	59
Eigenvalues of Unrotated Factors	5.08	1.17	.45	.44		5.01	1.16	.58	.54		3.91	1.72	.80	.68	

Note: Decimal points omitted from factor loadings.

Race/Ethnicity

Computation of subtest intercorrelations for the racial/ethnic subgroups revealed that whites did obtain consistently higher correlations than did blacks (range difference = .021 to .150, mean = .087) and that both subgroups did show consistently higher correlations than did Hispanics. For whites and Hispanics the range was .087 to .617 with a mean of .259 and for blacks and Hispanics the range was .000 to .581 with a mean of .174. Selection of the most readily interpretable factor solution for each racial/ethnic subgroup involved examination of the two- through five-factor solutions. The results of the four-factor solution in Table 4 indicate that even with fairly large differences in the size of correlations, the pattern of correlations among the subtests remained nearly constant across the racial/ethnic subgroups. One minor difference occurred for the Hispanic group. Whereas the high factor loadings for Hispanics across the four factors were quite similar to those for whites and blacks, the Speeded Performance Factor for Hispanics had a simpler structure--an outcome indicating that speeded performance for Hispanics had less overlap with the other ASVAB subtests. Examination of subtest loadings for the five-factor solution (not reproduced in this paper) for the racial/ethnic subgroups, again, points to the complexity of the technical knowledge construct. The same division in the Technical Knowledge Factor was seen for blacks as was observed for females. For Hispanics the factor also broke down, with AS and MC defining one factor and EI defining the second. The loadings for the fifth factor for these two subgroups were .31 and .40, respectively.

DISCUSSION

The purpose of this investigation was to examine the factor structure of the Armed Services Vocational Aptitude Battery (ASVAB), Forms 8, 9, and 10; to compare the factor structure to structures observed for previous samples and earlier forms; and to assess the similarity of factor structures for racial/ethnic and sex subgroups. Analyses indicated that ASVAB 8/9/10 measured dimensions in the FY81 aggregate Army applicant sample similar to those dimensions found for the service-wide male reference sample (Ree, Mullins, Mathews, and Massey, 1981) and to those dimensions measured by ASVAB Form 5 in the DoD high school testing program (Fischl et al., 1979). In addition, there appeared to be few important differences in the factor structure of Forms 8, 9, and 10 for gender and racial/ethnic subgroups for Army applicants. The analyses spoke to the invariance or constancy of factor content across forms and population subgroups. It is hoped that information about the test battery used in this large scale evaluation program is of interest to the scientific community.

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